32.8 **A locker room has 12 showers supplied with hot water from a steam heat exchanger. The shower heads are rated for $5GPM$ each. Expected demand can be estimated as 25% of maximum. Cold water enters the heat exchanger at $55°F$ and leaves at $115°F$. $500\frac{lb_m}{hr}$ of $5psig$ steam is supplied to the heat exchanger and leaves saturated. What is the efficiency of the heat exchanger?**

A. 90%

B. 92%

C. 94%

D. 96%

The heat transferred to the water is less than the heat given up by the steam due to losses. The efficiency is determined by calculating both quantities.

For the water side of the heat exchanger, use the sensible heating rule of thumb for water to find the heat added. Before solving, apply the diversity in the flow rate demand. It is not necessary to size the heat exchanger for all 12 shower heads to supply the full $5gpm$ simultaneously.

$$Demand = (12showers)\left(5\frac{gpm}{shower}\right)(.25) = 15gpm$$

$$\dot{Q}_w = 500gpm\Delta T$$

$$\dot{Q}_{water} = 500\,(15)\,(115-55) = 450,000\frac{Btu}{hr}$$

For the steam side of the heat exchanger, look up the latent heat of vaporization, h_{fg}, for $20psia$ steam in the steam table, Properties of Saturated Water by pressure. Make sure to convert $psig$ to $psia$ before obtaining values. Calculate the energy given up by the steam using $Q = m\Delta h$.

$$\dot{Q}_{steam} = \dot{m}\Delta h = \dot{m}h_{fg}$$

$$\dot{Q}_{steam} = \left(500\frac{lb}{hr}\right)\left(960\frac{Btu}{lb}\right) = 480,000\frac{Btu}{hr}$$

Calculate the efficiency of the heat exchanger.

$$\eta = \frac{\dot{Q}_{water}}{\dot{Q}_{steam}} = \frac{450,000\frac{Btu}{hr}}{480,000\frac{Btu}{hr}} = 93.75\%$$

Answer C